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SELECTION OF TECHNOLOGY FOR BATCH COMPACTION AND FORMATION OF PERFORATED LAYER

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An analysis of methods for batch compaction and molding is performed to ensure continuous operation of the energy-saving melting chamber with a perforated layer. Approaches to solving the problem of molding the chamber layer before the start-up are discussed.

One of the most promising solutions of the problem of power and material saving in melting processes (in particular, in glass melting) is changing over to new methods for organizing the process to ensure a deep complex regeneration of all power waste, as well as regeneration of solid, liquid, and vaporous entrainment. Such methods include implementing the process in a shaft melting chamber with a perforated layer of batch material (Fig. 1).

A batch material (a glass batch, phosphorite, etc.) filling the shaft constitutes a perforated checkerwork consisting of partitions between the gas channels and a periphery shell adjacent to the immobile enclosure of the shaft. The shell acts as bearing lining and a continuously renewable (mobile) vertical enclosure of the melting chamber. The gas channels have a common header in the bottom part of the batch layer. The combustion components are burned in the chamber header and are removed via the checkerwork channels, meanwhile becoming deeply cooled and heating the checkerwork to the melting point [1].

The checkerwork partitions are thermally less massive than the periphery shell. This ensures their faster heating and melting, which results in the formation of the gas header. The checker partitions consisting of the batch material ensures heat transfer from the waste gas. The heat treatment of the shell is implemented predominantly in the header, and its melting continues up to a thickness at which the shell becomes plastically deformed under the gravity of the perforated layer, which provides for continuous motion of the batch layer in the chamber. The deformed shell with melt flowing along its inner surface arrives at the tank, where the batch melting processes are completed.

The use of the thermal engineering principle of a perforated layer significantly increases the temperature level of the melt, which intensifying the process, deeply cools the waste gases, decreases heat transfer via the working space enclosure, and extends the furnace campaign (USSR Inventor's Certif. Nos. 1047847, 1058901, 1161502, 1167155, 1222635, 1276627, and 1486482) [2, 3]. The advantages of the specified thermal engineering principle become especially significant in continuous molding of the perforated layer of the batch material directly on the furnace top when

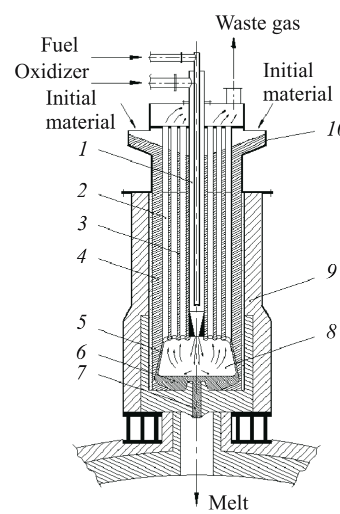

Fig. 1. Fundamental scheme of a shaft melting chamber with a perforated layer: *1*) axial channel with a burner; *2*) gas channel; *3*) partitions comprising the checkerwork; *4*) peripheral shell; *5*) melt film; *6*) melt tank *7*) tap-hole; *8*) gas header; *9*) shaft enclosures; *10*) furnace top.

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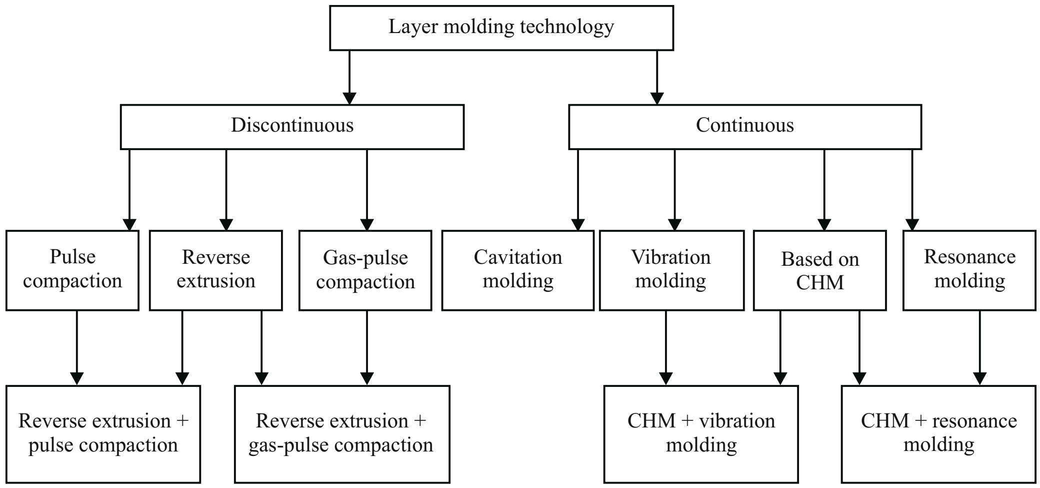

Fig. 2. Classification of promising methods for forming perforated layer.

the molding process is combined with drying and compaction of the material.

The current level of molding (compaction) technology makes it possible to obtain molded briquettes of required density and strength from powder materials and their composites. Molding involves the coalescence of solid particles of various sizes, shapes, compositions and structural-mechanical properties, which is accompanied by the compaction of the briquette structure. The choice of equipment and molding methods depends on the composition and properties of batches and on the requirements imposed on molded briquettes charged into the furnace and on the melt at the exit from the furnace.

The processes of batch compaction are classified based on the phase state of the components as follows [4, 5]: from a mixture of the solid and the liquid phases, for instance, in preparing briquettes from cold-hardening mixtures (CHM); from a solid phase; from a moistened batch or a batch with plasticizing additives.

The compaction of glass batches and chemical reactions involved in this process occur consecutively or simultaneously, depending on binders and technological conditions. A compaction process may be accompanied by the thermal shrinkage of briquettes if it is combined with the heat treatment process.

The efficiency of glass batch compaction depends on the method used and on the equipment, which can be classified into compression (using plates, shock method, or explosion), casting, extrusion (squeezing through the matrix channels), or reverse extrusion,

Methods for molding glass batches are classified into groups [4]:

– dry molding — without a liquid phase; a briquette is formed under the effect of molecular and electrostatic forces or by indenting particles into each other;

– boundary formation — as a result of the presence of a small quantities of absorption liquid layers between particles; the difference of the properties of the liquid and the particles facilitates the formation of the briquette;

– moist molding — proceeds by the interaction of particles with a viscous liquid whose hydrodynamics is the critical factor in granule formation;

– forming a solid skeleton of crystallization structures emerging as a result of chemical reactions or under the effect of binding materials leading to hardening;

– press molding — forming a briquette macrostructure with a dense packing by means of substantial deformation of a disperse system using shear, compression, or compression combined with shear.

The equipment used for these molding methods has various design solutions and its choice depends on the characteristics of batches and the molding and compaction method.

The development of a charging-molding unit (CMU) for a shaft melting chamber with a perforated batch layer implies selecting methods for batch preparation, molding, and charging. Some known methods include batch preparation, molding, feeding, and charging finished briquettes into the furnace shaft. In such case high requirements are imposed on the strength of briquettes and removal of briquettes destroyed or damaged in charging, furthermore, the gas channels of a loaded briquette have to be combined with the channels of briquettes that had been loaded before.

It is advisable to develop new charging methods to exclude the transportation and placement of briquettes in the shaft. Such a method should include feeding a prepared batch mixture onto the top of the shaft furnace into a CMU, its uniform distribution across the shaft section, and then molding and compaction of briquettes directly in the CMU. Molding methods can be classified into discontinuous and continuous, with the respective requirements for feed and distribution of the batch material across the shaft section (Fig. 2).

The system of batch distribution over the shaft section is needed for implementing all discontinuous molding methods and some continuous ones. Such system can be based on me-

chanical and vibration methods or on resonance impact upon the batch.

Whereas the mechanical and vibration methods are more or less tested and approved [5, 6], the use of resonance impact calls for additional investigation. At the same time, most continuous methods make it possible to do without a system of batch distribution across the shaft section.

The following variants of discontinuous molding and compaction of a perforated layer are possible [7, 8]: reverse extrusion, pulse compaction, gas-pulse compaction, and reverse extrusion with pulse or gas-pulse compaction. As a rule, all discontinuous variants have a common disadvantage: the impact of the molding force on the underlying batch layer and on the working chamber enclosure.

The methods and technologies of continuous molding [4 – 10] are as follows: molding using CHM, vibration, resonance, and cavitation molding.

In implementing a continuous method (for instance, the CHM method) in a CMD it should be taken into account that the CMD work depends on the force of adhesion of the batch material to the molding unit surface. At the same time, a combination of continuous molding with surface vibromolding and vibrocompaction, with resonance impact transmitted through the CMD body, or with cavitation that creates a gaseous layer between the material and the CMD surface, can reduce this force of adhesion to a negligibly low level.

The applicability of molding methods and technologies can be determined by the geometrical parameters of the perforated layer and the strength parameters of the molded material. Hence the need for the calculation analysis of the dependence of the shaft size on the furnace output and the perforated layer geometry, as well as experimental study of the strength parameters of briquettes (the particular batch type) obtained by various methods.

The specified technologies of molding a perforated layer in a CMD concern the operating regime of the furnace. However, the operating regime cannot be implemented without a preliminary preparation of this layer. Its main challenge is to fill the shaft with a material and produce the configuration of the gaseous space of the layer, i.e., the header and the gas channels (Fig. 1).

To solve this problem, the following methods for the preliminary preparation of a perforated layer can be proposed:

– preliminary formation of a working chamber from the perforated layer and its subsequent charging and installation in the furnace shaft;

– simulating the gaseous space of the layer by means of combustible or fusible materials;

– simulating the gaseous space by inflated molds;

– simulating the gaseous space by ferromagnetic liquids.

The preliminary molding of the working chamber of the perforated layer (method 1) can be carried out similarly to molding concrete products or large casting molds. The subsequent transportation and installation of the molded batch into the furnace shaft requires not only a special charging unit, but also additional measures to improve the strength parameters of the molded elements of the perforated layer. Furthermore, the need for transportation restricts the maximum size of the perforated layer section depending on the strength characteristics of the molded work chamber elements.

The application of products simulating the configuration of the gaseous space in the perforated layer makes it possible to fill the working chamber directly on site (in the furnace shaft) and avoid its transportation and installation (loading).

A simulator product can be made of plastics or other combustible materials (method 2). If the simulator burns out after the furnace is started; this may influence the product quality at the initial stage of the furnace operation depending on the material selected for the simulator.

The use of simulators may influence the minimal size of the gas channels in the work chamber, since these simulators occupy part of the channel section area. Requirements on the strength of simulators and charging technology may restrict the maximum section area of the working chamber, as well as the molding rate of the perforated layer, considering the need to observe the drying regime for the batch material.

Inflated molds of the working chamber (method 3) made of film materials in the form of elastic shells (pneumatic jacks) have sufficiently high strength. Using this method, the configuration of a gas header with channels can be simulated by a single simulator or by several ones. In the latter case the simulator products join and simulate a single gas header.

Method 4 is based on the capacity of a disperse ferromagnetic system to change its rheological properties when the magnetic field strength varies. A simulator is installed into the shaft and filled with a ferromagnetic liquid, which under the effect of the magnetic field instantly registers and retains the simulator configuration. The use of the ferromagnetic method for preliminary preparation removes the limitation of Method 3 with respect to the minimum size of the gas channel for discharging the combustion products from the gas header.

Solving the problems of the perforated layer formation during the operation of the chamber and of molding a layer in the prestart period will provide the basis for the industrial implementation of the energy-saving melting plant.

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